

# Report on Cerebro-Spinal Fever in the Royal Navy.

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THE cases of cerebro-spinal fever in the Royal Navy from August, 1914, to July 31, 1915, have been investigated by order of Sir Arthur May, K.C.B., Director General, with the main object of determining what measures should be adopted to prevent or minimize an epidemic outbreak of this disease in the coming winter of 1915-1916. The enclosed report contains—

- (I) A discussion of the etiology of the cases.
- (II) A history of the outbreaks at various centres.
- (III) A summary of the rarer manifestations and complications.
- (IV) A summary of the results of treatment.
- (V) Recommendations as to prevention (i) of the disease and (ii) of its spread.

## (I) ETIOLOGY OF THE CASES.

The cases of cerebro-spinal fever in the Royal Navy amount to 170, of which 90, or 52·9 per cent., proved fatal.

*Incidence.*—The cases naturally occurred mainly where large numbers of ratings were collected.

There were 33 cases at the Crystal Palace ; 21 cases at the Royal Naval Barracks, Chatham ; 25 cases were traced to Deal ; 16 occurred in the Royal Naval Barracks, Portsmouth, which at the time was not

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over-crowded; there were 15 cases at the Royal Naval Barracks, Devonport; 12 cases at the Royal Marine Artillery Barracks, Eastney; and 10 cases in the "Impregnable."

In some instances, however, large numbers of men were collected together without a corresponding incidence of the disease.

At Blandford, although drafts from infected centres (the Crystal Palace and Deal) were received, six cases only occurred, three of which were in the Deal Battalion, which was isolated from the rest of the camp until February 20, between February 1 and 4, or shortly after their arrival from Deal, and must therefore be regarded as having originated at Deal. At the Royal Marine Light Infantry Barracks, Forton, no cases really originated, although four cases were borne on the books. On the "Powerful I" there were two cases only, both on April 10, when there were 600 boys.

The disease may occur in sudden outbursts, so as to suggest a virulent focus or the presence of carriers inside a barracks, or may crop up in an intermittent or isolated fashion, so as to point to infection contracted outside.

Thus at Deal 13 cases occurred between January 19 and February 4, and no cases after March 14. In the "Impregnable" 5 cases occurred between February 8 and 12, and none between February 24 and May 30. At Eastney 4 cases, 3 of which could be traced to a probable source of infection in the barracks, occurred between January 18 and 20.

On the other hand, at the Royal Naval Barracks, Portsmouth, 16 cases occurred in six months (January 27 to July 31), the most in any one month (March) being 4. In addition, 2 men went sick with the disease shortly after leaving the barracks.

In the Royal Naval Barracks, Chatham, the cases occurred in such continuity from January 27 to March 17 as to suggest an internal origin; after that date there were 3 cases only, and of these 2 could be traced to outside infection. At the Royal Naval Barracks, Devonport, there were 7 cases between February 12 and March 4, and then no more until infection was introduced from outside on March 21. Twelve cases occurred in sea-going ships, and in one instance only did two cases occur in the same vessel (the "Biarritz").

*The monthly incidence* with the results is shown below. The largest number of cases and of deaths occurred in February:—

Month	Cases	Deaths	Invalidings	Recoveries
November ..	1 ..	0 ..	1 ..	0 ..
December ..	2 ..	1 ..	0 ..	1 ..
January ..	27 ..	16 or 59 per cent. ..	1 ..	10 ..
February ..	60 ..	35 „ 58 „ ..	1 ..	24 ..
March ..	35 ..	15 „ 42·8 „ ..	3 ..	17 ..
April ..	24 ..	8 „ 33·4 „ ..	0 ..	16 ..
May ..	12 ..	8 „ 66·7 „ ..	1 ..	3 ..
June ..	6 ..	4 ..	— ..	2 ..
July ..	3 ..	3 ..	— ..	— ..
	<hr/> 170	<hr/> 90		



*The Question of the Communicability of the Disease.*—It has been authoritatively stated that a very definite feature of epidemics of cerebro-spinal fever is the isolation or want of ascertained contact between the cases of the disease, and it has even been suggested that it is not more communicable than pneumonia, and in this connexion the extreme rarity of infection of medical officers and nurses in hospital might be mentioned. This is an important point, for if the etiology of the disease is on the same plane as that of pneumonia, it would not be worth while to attempt isolation of meningococcic carriers.

Out of the 170 cases some evidence of infection was traced in 59, or rather more than a third; this is by no means convincing proof of the communicability of the disease, but it should be stated that the opportunities for tracing the infection, which appears to be largely conveyed by carriers, varied in different places, especially as to contact with carriers. At Chatham infection was traced in 12 out of 24 cases, whereas among 33 cases at the Crystal Palace the infection was traced in 8 only, and among 20 cases at Deal a connexion was forthcoming in three instances only. It is obvious that the more the cases can be investigated the larger the number in which the source of infection is traced.

The following points noticed among the cases in the Navy are in favour of the view that the disease is spread from one individual, either suffering from the disease or a carrier, to another.

(1) Spread of the disease from an infected focus.—A draft of men of the Naval Brigade from Deal carried the disease to the camp near Blandford, where at least one man, who was in billets and went sick, appeared to have communicated the disease to a civilian living in the house. In Portsmouth where there was one civilian case in 1914, as contrasted with sixty-two in 1915 up to June 22, the first civilian case was in a child aged  $4\frac{1}{2}$  years on February 11, who attended the Royal Naval Artillery School, Eastney, in which recruits were also taught. By this time six recruits from Eastney had gone down with cerebro-spinal fever, the last on February 9. During the following eight days four other children of about the same age in the neighbourhood of Eastney became infected.

(2) The way in which outbreaks appear to be stopped by isolation of contacts and mild disinfection of the throat.

In the "Impregnable" 5 cases occurred between February 8 and 12; on the two following days 123 contacts were removed to the Royal Naval Hospital, Plymouth, and of these 31 were found to be carriers, 2 of which

developed the disease on February 15 and 19 respectively. On February 19, a boy on leave developed the disease, but otherwise no case could be traced to the "Impregnable" until a boy, who left that ship on April 3, developed the disease on the following day in the Royal Naval Barracks, Portsmouth. On April 10, 2 cases of cerebro-spinal fever occurred in the "Powerful I" in a mess where a carrier was afterwards found, who, fifty-six days previously had had "influenza in a severe form" (possibly cerebro-spinal fever) at Liverpool. Fifty-five contacts were segregated (15 carriers), and no further cases occurred. At the Royal Naval Barracks, Chatham, 5 cases occurred among the engine-room artificers, between February 1 and March 17; 130 men were examined; 30 of these had nasal or faucial catarrh, and of these 3 were found to be carriers and were isolated. After this no more cases occurred among the engine-room artificers. At Deal all the men using the swimming bath sprayed their throats with a mild antiseptic before bathing, and no case occurred after March 14.

(3) The difference between the incidence of the disease in barracks and institutions in the same port.

In the Portsmouth district at the Royal Marine Light Infantry Barracks, Forton, no case originated (although 4 cases were borne on the books), whereas at the Royal Marine Artillery Barracks there were 10 cases at least, and at the Royal Naval Barracks, Portsmouth, 16 cases. On the hypothesis that cerebro-spinal fever is not more infectious than pneumonia its incidence, other things being equal, should be in proportion to the number of men in the respective barracks, namely, the Royal Marine Light Infantry Barracks, 1, the Royal Marine Artillery Barracks  $1\frac{1}{4}$ , the Royal Naval Barracks, Portsmouth,  $5\frac{3}{4}$ . This proportion was not shown, for at the Royal Marine Artillery Barracks, Eastney, where there was, as already mentioned, an outburst of cases suggesting an internal focus of infection, there was relatively a great excess over the other two. At the Royal Naval College, Osborne, no case has occurred.

(4) The detection of carriers who have been in contact with cases of the disease and have formed a bridge between them. This was shown to occur in several instances at the Royal Naval Barracks, Chatham, by Deputy Surgeon-General C. J. Mansfield, M.V.O.

The experience of the cases of cerebro-spinal fever in the Navy is therefore in favour of the usually accepted opinion that the disease is communicable, and that precautions to prevent infection are necessary.

*The spread of the disease* depends in the first instance on infection from (a) carriers, (b) abortive and undetected cases, (c) patients recognized to be suffering from the disease. The first two are the most important, whereas the last is so obvious as not to require discussion. An attack of the disease, however, may be



followed by a chronic carrier state, which may possibly be periodic or intermittent, with positive and negative bacteriological results alternating.

A case of cerebro-spinal fever at the Crystal Palace had been in contact with a man who, after recovering from the disease, had returned to duty; on bacteriological examination he was found not to be a carrier (*vide* p. 22); in this instance the spread of infection was not proved, but possibly he was a periodic carrier. In September, after the period covered by this Report, an outbreak of three cases of cerebro-spinal fever among boys in the Royal Naval Barracks, Portsmouth, was traced to a boy who had recovered from the disease and returned to duty; bacteriologically he was proved to be a carrier (Fairer).

(a) *Carriers*.—This is a most important and difficult question in connexion with the spread of the disease. If carriers could be entirely eliminated the disease would be abolished, and the prophylaxis of cerebro-spinal fever is largely concerned with the detection, isolation, and sterilization of carriers (*vide* p. 32 *et seq*). It is probable that under conditions which depress their resistance carriers would be become attacked by the disease, and this reasonable assumption would explain the occasional occurrence of very long incubation periods.<sup>1</sup> It is therefore remarkable how rarely known carriers contract the disease; among 170 cases of cerebro-spinal fever there were 3, or 1·7 per cent., in recognized carriers under treatment; these 3 cases occurred among the 227 carriers detected around 120 cases, or a percentage of 1·3. The importance of carriers is therefore mainly that they may convey the disease to others.

The difficulties lie in (1) the detection of healthy carriers; this could only be attempted by the examination of every man in the Service, and as the carrier state is usually of short duration (about three weeks), and as some carriers are intermittent, showing the presence and absence of meningococci alternately, the work thus involved would be prohibitive.

(2) The discrepancy as to the numbers of carriers among contacts. Thus some authorities, for example Flügge, have found that as many as 70 per cent. of close contacts are carriers, while others have estimated the percentage as low as 7 (von Lingelsheim). In the Navy the results have varied considerably; this probably depends on the employment of different standards in the bacteriological diagnosis at various centres.

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<sup>1</sup> The French memorandum states that the incubation period may be as long as thirty-six days (*vide Brit. Med. Journ.*, 1915, i, p. 521).

At Plymouth, out of 402 close contacts 97, or 24 per cent., were positive, and out of 1,056 remote contacts 74, or 7 per cent., were positive (Whiteside). At Deal, among 97 close contacts 16 were positive, while of 35 remote contacts none were positive (E. A. Shaw). Out of 122 close contacts from the Crystal Palace 12, or 9 per cent., were positive (Bassett-Smith). At Chatham, out of 243 who were sleeping next to or in the same mess as a case of cerebro-spinal fever, 20, or 8·5 per cent., were positive (Dudley). At Portland, out of 58 close contacts 5, or 8·6 per cent., were positive (Shand and Hitch). Out of 222 close contacts examined at the Royal Naval Hospital, Haslar, there were 2, or 0·9 per cent., positive (Dudding).

(3) The present state of our knowledge as regards the morphology of the infective agent of cerebro-spinal fever. It has recently been suggested that the meningococcus is only a phase in the cycle of a pleomorphic micro-organism which causes the disease.<sup>1</sup> If so, this would bear on the failure to recognize carriers and so to limit the spread of the disease.

(4) The possibility that the disease may be conveyed by carriers other than human beings, such as lice, fleas and other parasites, the virus passing direct into the circulation, is at present hypothetical, but it is worth consideration from the point of view of prophylaxis.

(b) *Abortive Cases.*—The existence of such cases is likely to be detected only when an epidemic is in progress; at other times they may be regarded as “influenza” or “catarrh.” Such cases may occur among those in contact with the sick, and their occurrence among relatives, nurses, and medical attendants should be borne in mind. The first or catarrhal stage of cerebro-spinal fever may be prolonged, and during this period be indistinguishable from influenza; some of the cases in the Navy have been of this nature and have been instrumental in spreading the disease.

At the Crystal Palace three cases occurred among the Public Schools Battalion between February 10 and 14; one of them had been ill with catarrh since January 28, and among his contacts three positive cases were found.

The disease may abort in the catarrhal stage, and these cases are more active in the spread of the malady than the cases which run the characteristic course and are therefore isolated.

A man in the Naval Brigade at the Crystal Palace went sick with what was thought to be influenza on March 16. He went home, and subsequently his wife and child died of cerebro-spinal fever. On

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<sup>1</sup> Hort, Lakin and Benians, *Brit. Med. Journ.*, 1915, vol. i, pp. 541, 715.



March 31 he was admitted to the Croydon Hospital, where he was regarded as a case of cerebro-spinal fever, although lumbar puncture was not performed.

The coincidence of a high sick-rate of catarrhal affections (influenza, catarrh, tonsillitis, sore throat) with the occurrence of cases of cerebro-spinal fever has been noted in several though not in all instances, and it may be pointed out that not only may catarrhal affections dispose to meningococcic infection, but that some patients regarded as "catarrh" or "influenza" may be abortive cases of cerebro-spinal fever.

*Conditions which may favour the Spread of the Disease.—*

(1) Overcrowding is a recognized factor in favouring the outbreak of the disease. It appears to act by increasing the number of carriers, and probably by spreading other diseases, such as influenza and catarrh, which weaken the patient's resistance and thus favour the carrier state or virulent meningococcic infection.

In connexion with the influence of overcrowding on the incidence of cerebro-spinal fever attention may be drawn to the Royal Naval Barracks, Devonport, where twelve out of the fifteen cases of the disease occurred in the blocks with the lowest cubic space (*vide* p. 18.)

The danger of overcrowding must not be estimated solely in terms of cubic space, for in summer, when men are more in the open and are less tempted to circumvent proper ventilation, overcrowding is less productive of cerebro-spinal fever than in winter. Overcrowding to an extreme degree may occur without cerebro-spinal fever, provided infection is obviated. Thus in both the "Powerful" and the "Impregnable" there is great overcrowding, but in both, on the appearance of the disease, isolation of contacts and removal of carriers were followed by stoppage of the outbreak. Conversely an outbreak may occur in the absence of overcrowding; thus at Eastney five cases occurred between January 15 and 20, when the number of men was considerably under the full complement.

(2) Catarrhal affections—catarrh, influenza, tonsillitis, and sore throat—were numerous during the early months of 1915, and their prevalence roughly coincided with the outbreak of cerebro-spinal fever. The greater prevalence of catarrhal affections in the first quarter of 1915 as compared with the first and last quarters of 1914, as shown at Deal and Shotley, suggests some connexion with the cerebro-spinal epidemic.

In some barracks and establishments the maximal incidence of

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cerebro-spinal fever occurred in the month during which catarrhal affections were most numerous.

At the Royal Marine Artillery Barracks, Eastney, both catarrhal affections and cerebro-spinal fever were at their maximum in January; at the Royal Naval Barracks, Chatham, at the Crystal Palace, and in the "Impregnable" this occurred in February.

At these centres there was some evidence that carriers existed among the occupants, and it is therefore justifiable to suggest that the prevalence of catarrhal affections favoured the carrier state and facilitated infection. In support of this contention it may be mentioned that at the Royal Marine Light Infantry Barracks, Forton, catarrhal affections were few and no cases of cerebro-spinal fever originated in the barracks. In the "Powerful," where two cases only occurred on April 10—a month which had a small incidence (68) of catarrhal affections as compared with the preceding month (March having 136, the highest for the first half of the year)—15, or 27 per cent., carriers were found among 55 contacts; at first sight it might appear that these circumstances militate against the view that a high incidence of catarrhal diseases favours the carrier state. But reflection shows that as the two cases and the detection of carriers occurred early in April, the influence of the high incidence of catarrhal diseases in March was still active.

In the Royal Naval Barracks at Portsmouth and Devonport, there was no exact relation between the incidence of catarrhal diseases and of cerebro-spinal fever. In both of these instances there was a dearth of evidence of a focus of infection inside the barracks, and it is perhaps reasonable to suppose that the cases were mainly introduced from without.

In conclusion, there appears to be a relation between the incidence of catarrhal affections on the one hand and of cerebro-spinal fever cases on the other.

(3) Age incidence. In civilian practice cerebro-spinal fever is pre-eminently a disease of childhood and adolescence. Among the 170 cases in the Navy, 103, or 60·6 per cent., occurred under 20 years of age, and the number of cases progressively diminished in each successive decade while the mortality percentage rose. This is shown in the following table:—

Age-periods	Number of cases and percentage of the total 170 cases		Deaths and percentage in the age-periods
15—19 ..	103 or 60·6 per cent.	..	45 or 43·7 per cent.
20—29 ..	43 „ 25·3 „	..	27 „ 62·8 „
30—39 ..	13 „ 7·6 „	..	10 „ 76·9 „
40—49 ..	8 „ 4·8 „	..	6 „ 75·0 „
50—59 ..	3 „ 1·7 „	..	2 „ 66·7 „



It must, however, be remembered that there was a very large number of young recruits in the Navy, and that there are probably special factors at work which dispose them to cerebro-spinal fever.

(4) Recent enlistment. Newly joined recruits were specially attacked by the disease.

At the Royal Naval Barracks, Devonport, there were 15 cases of cerebro-spinal fever; of these 1 had been in the Service over a year, and the remaining 14 were recent recruits with an average of thirty days' service. Of 21 cases at the Royal Naval Barracks, Chatham, 11 were recent recruits with an average service of twenty-four days (7 with less than twenty days' service, and 1 with eighty-eight days' service).

Youth is generally recognized as a factor favourable to the incidence of cerebro-spinal fever, but in addition the following factors lower the vital resistance of recent recruits: (*a*) Depression and home-sickness, comparable with that of a boy during his first term at school; (*b*) vaccination on entry and antityphoid inoculation in the Naval Brigade; (*c*) fatigue and over-exertion due to drills and marches. The effect of fatigue was shown in the Deal Battalion, which left Deal on January 24 to march to Maidstone, stopping the first night at Littlebourne, the second at Charing, and the third at Bearsted; the next day (January 27) three men went sick with cerebro-spinal fever at Maidstone. The battalion then went by train to the camp near Blandford, where three more men went down with the disease on February 1, 3, and 4.

In the following case, investigated by Fleet-Surgeon R. Hill, C.V.O., the three factors—overcrowding, the depressing effect of antityphoid inoculation, and fatigue—were all present. A private, aged 19, who occupied a room with 250 cubic ft. of space in Upper Walmer, was inoculated against typhoid fever on February 22, 1915; next day, although feeling out of sorts, he did a hard day's work, and at 7 p.m. went by train to Sandwich, where there had recently been an outbreak of cerebro-spinal fever. On February 24, he felt ill and stayed in bed, and on the following day was delirious and found to have cerebro-spinal fever.

(5) Meteorological conditions might naturally be expected to exert some influence on the incidence of cerebro-spinal fever. Thus east and north winds and a low atmospheric temperature, or a sudden fall of temperature, might, by reducing the resistance to bacterial invasion, lead directly to meningococcic infection, or by favouring other infections of the naso-pharynx dispose to the carrier state. During the epidemic it appeared to many medical officers that cases came under observation in connexion with a cold snap, and were less frequent when the weather was warm and calm. It therefore seemed worth while to investigate the relation, if any,

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between the direction of the wind and the daily temperature, on the one hand, and the occurrence of cases of cerebro-spinal fever on the other. It may be said at once that the results do not justify any definite conclusion.

In the first instance the monthly incidence of cerebro-spinal fever was compared with the prevailing winds, and it appeared that there was some evidence to support the preconceived view that northerly and easterly winds favour the occurrence of the disease. At Portsmouth, Plymouth, and Deal cases of the disease followed in the wake of north and east winds, but at Chatham no decided conclusion as to the influence of winds was forthcoming. The direction of the wind on (*a*) the day of onset of the disease and (*b*) on the three previous days was then plotted out for 93 cases occurring at Portsmouth, Plymouth, Chatham, and Deal. On the actual day of onset the wind was more or less east or north in 50 cases, and south, west, or calm in 43. On the three days before the onset of the disease the wind was more or less east or north in 47, south or west in 35, and in 11 cases varied during the three days. On the whole, there is not sufficient evidence that east and north winds play an important part in causing an outbreak of the disease.

The question of the atmospheric temperature was gone into. In some, but not in all instances, the months with the lowest average daily temperature showed the largest number of cases of the disease, but the difference in the average daily temperatures was so comparatively small that no conclusion as to its influence is justified.

In the Portsmouth district the larger number of cases occurred in January ( $T. = 46^{\circ}$  F.) and March ( $T. = 46^{\circ}$  F.), and fewer in February ( $T. = 49^{\circ}$  F.) and April ( $T. = 54.4^{\circ}$  F.). At Chatham more cases were seen in February ( $T. = 38^{\circ}$  F.) than in January ( $T. = 40^{\circ}$  F.), March ( $T. = 42^{\circ}$  F.), or April ( $T. = 49^{\circ}$  F.). At Deal 7 cases occurred in January ( $T. = 44.4^{\circ}$  F.), 10 in February ( $T. = 45^{\circ}$  F.), and 3 in March ( $T. = 48^{\circ}$  F.). At Plymouth, however, no such relation existed.

As a sudden fall of temperature might reduce the vital resistance to infection, this question was investigated. The temperatures (day and night) for three days before the onset of the disease in 93 cases from Portsmouth, Plymouth, Chatham, and Deal were examined in order to see if there was a sudden fall of temperature of  $10^{\circ}$  F. or more within this period. Out of the 93 cases there was such a fall in 37 only, and not in the remaining 56. There is, therefore, no reason to believe that a sudden fall of the atmospheric temperature causes an immediate outbreak of the disease.

Finally an enquiry was made as to the relation between the



prevailing wind and the average daily temperature combined and the incidence of cerebro-spinal fever. Consideration of the monthly incidences of 82 cases of cerebro-spinal fever with the prevailing winds and the average daily temperature for January to March at Portsmouth, Plymouth, Chatham, and Deal shows that practically half the cases occurred in February, during which the prevailing wind was south-west and the average daily temperature  $43.5^{\circ}$  F., whereas in January the wind was west or south-west in the first half and north or north-east in the second half, and the average daily temperature  $43.7^{\circ}$  F.; in March the prevailing wind was north-east and the average daily temperature  $45^{\circ}$  F. There is not, therefore, any real evidence that north and east winds and a low atmospheric temperature play a causal part in the outbreaks of cerebro-spinal fever.

*January, 20 Cases.*

Portsmouth	10 cases ;	the coldest month there ( $46^{\circ}$ F.) ; prevailing wind					1st half W. & S.W. 2nd half N. & N.E.
Deal	7	„	„	„	„	( $44.4^{\circ}$ F.) „ „	
Chatham	3	„ not the coldest month there ( $40.8^{\circ}$ F.) „ „					
Plymouth	0	„	„	„	„	( $45^{\circ}$ F.) „ „	

*February, 40 Cases.*

Chatham	9	cases ; the coldest month there (38° F.) ; prevailing wind S.W.						
Plymouth	17	„	cold month there		(43·8° F.)	„	„	„
Portsmouth	4	„	not the coldest month there		(49° F.)	„	„	„
Deal	10	„	„	„	„	(45° F.)	„	„

*March, 22 Cases.*

Plymouth	3	cases; cold month there (43·8° F.) ; prevailing wind N.E.				
Chatham	5	,, not the coldest month there (42° F.) ,, ,, S.W.				
Portsmouth	11	,, ,, ,, ,, (47° F.) ,, ,, N.E.				
Deal	3	,, ,, ,, ,, (48° F.) ,, ,, ,,				

## (II) HISTORY OF THE OUTBREAKS OF CEREBRO-SPINAL FEVER AT VARIOUS CENTRES.

### THE PORTSMOUTH DISTRICT.<sup>1</sup>

The 36 cases treated in the Royal Naval Hospital, Haslar, were drawn from the Royal Naval Barracks, Portsmouth (16 cases), the Royal Marine Artillery Barracks, Eastney (12 cases), the Royal Marine Artillery Barracks, Forton (4 cases), and 3 isolated cases from the "Excellent," the "Vernon," and the "Fisgard" respectively.<sup>2</sup>

<sup>1</sup> A report on 31 cases treated at the Royal Naval Hospital, Haslar, was made by Staff-Surgeon B. S. Robson, R.N., and Temporary Surgeon L. Pearce Gould, R.N., in the JOURNAL OF THE ROYAL NAVAL MEDICAL SERVICE, 1915, vol. i, No. 3, pp. 255-269.

<sup>2</sup> One case, admitted on March 1 to Haslar from the Royal Naval Barracks, Portsmouth, with German measles, developed cerebro-spinal fever on March 10; as the medical officer who attended this patient also looked after the cerebro-spinal cases, and

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In Portsmouth the total number of cases among civilians (including the dockyard cases) up to June 22 was 62. At the Alexandra Hospital, Cosham, which serves a large military area, there were 49 cases of cerebro-spinal fever from January 1 to August 14. The first naval case in the Portsmouth district was a private at the Royal Marine Artillery Barracks, Eastney, on January 15; the first military case was reported on January 19 in the Royal Field Artillery, Hilsea; and the first civilian case on February 11, in a boy aged  $4\frac{1}{2}$  years, close to Eastney Barracks, and probably infected from that source (*vide* p. 3). Out of the 36 cases treated at the Royal Naval Hospital, Haslar, the source of infection was traced in 17. Of the 36 cases, 19 proved fatal, a mortality of 52·7 per cent.

In the Portsmouth district the monthly incidence of cases in the Navy was as follows: January 10, February 4, March 11, April 3, May 4, June 3, July 1. This incidence was compared with the following meteorological conditions, forwarded by Fleet-Surgeon G. T. Broatch: the direction of the wind, the saturation of the atmosphere with water, and the day and night temperatures from January 1 to April 30. Up to January 15, when the first case occurred, the wind was west and south-west; for the rest of the month it was north and north-east. In February the prevailing winds were west and south. In March the winds were west up till March 6, after this they were mainly east or north. In April the wind was mainly south-west. It therefore appears that north and east winds favour the incidence of cerebro-spinal fever, whereas south and westerly winds do not. The average daily temperature in January was  $46^{\circ}$  F.; in February  $49^{\circ}$  F.; in March  $47^{\circ}$  F.; and in April  $54\cdot4^{\circ}$  F. A lower daily temperature, with east or north wind, appears to coincide with an increased incidence of cerebro-spinal fever. The saturation of the atmosphere with moisture and the difference between the day and night temperatures did not appear to exert any influence on the incidence of the disease.

*The Royal Naval Barracks, Portsmouth.*—The first case of cerebro-spinal fever occurred on January 27, and at this time there was little, if any, overcrowding. The only mess in which a certain amount of overcrowding has been unavoidable, namely, that of the chief petty officers, has never had any case of cerebro-spinal fever. In March, 1915, arrangements were made to allow 500 cubic feet space to each man.

Sixteen cases occurred in the barracks in six months (January 27 to July 31), the most in any one month (March) being 4. This sporadic incidence and the evidence as to the source of infection, as far as it goes, justify the conclusion that the disease was in most instances contracted outside. In addition to these 16 cases, two men developed cerebro-spinal fever shortly after being drafted from the barracks. Most of the cases were in young recruits; 13 of the patients were under 20 years of

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had a bad cold at the time, it is just possible that he acted as a carrier, and that the infection was contracted in Haslar and not at the Royal Naval Barracks, where the last case occurred on February 24, in a signalman who left the Crystal Palace on February 20. On the other hand, the occurrence of German measles may have either converted the patient, supposing he was a carrier, into a case of cerebro-spinal fever, or have prolonged the incubation period of cerebro-spinal fever. As there is this doubt about the origin of infection, the case is not included among those originating in the barracks.



age (with seven deaths); the remaining 3 were between 20 and 30 years of age, and were all fatal. The average age of all the cases was 18·5 years, and of the 10 fatal cases 19·9 years.

The probable source of infection was traced in 8 cases. The first case, on January 27, contracted the disease at Chichester. In the second case, on January 30, the source of infection was not traced. There were 3 cases in February; the third (February 5) was not traced; the fourth (February 9) was in the same mess as the first case (January 27), and the fifth (February 24) had arrived four days before from the Crystal Palace, where there had been 11 cases in the first sixteen days of February. There were 4 in March; 1 was not traced, 2 probably contracted the disease in Gosport, where there was a small outbreak at the time, and the other may have caught the disease from the fifth case. Up to the end of March there were 9 cases, of which 7 proved fatal and 1 was invalided, whereas after that date there were 7, with 3 deaths and 1 invaliding. In April there was 1 only—a boy, who arrived the day before from the “Impregnable III” where, however, there had not been any case since February, and none occurred till May 30; moreover, he came from a mess in which no instance of the disease had appeared. In May, 2 cases occurred in boys drafted from the “Impregnable III” from a mess in which a case occurred on February 11, seven and fourteen days previously. One of them was left permanently blind. In June there were 3 cases, on the 10th, 25th, and 28th, which could not be traced; and there was another on July 30.

A tabular statement of the monthly incidence of influenza, catarrh, tonsillitis and sore throat did not reveal any relationship between their prevalence and that of cerebro-spinal fever. This negative evidence may be correlated with the view that there were not many active carriers in the barracks, for prevalence of catarrhal affections would tend to favour the carrier state and the outbreak of cerebro-spinal fever.

Month	Cases of cerebro-spinal fever				Cases of influenza, catarrh, tonsillitis, sore throat	
January	..	..	2	..	..	185
February	..	..	3	..	..	203
March..	..	..	4	..	..	157
April ..	..	..	1	..	..	204
May ..	..	..	2	..	..	172
June ..	..	..	3	..	..	133

Out of 132 contacts examined bacteriologically, only one was positive (Dudding).

*Royal Marine Artillery Barracks, Eastney.*—As the first case in the Portsmouth district occurred in these barracks on January 15, and as it was suggested that the infection was introduced into the barracks by a Canadian team which came to play football against the barracks on January 9, this question was discussed in a previous report which may now be summarized. It is known that four cases of cerebro-spinal fever occurred in the camp at Valcartier, in Canada, that there were three cases during the voyage to this country, and many in their camp on Salisbury Plain; but none of this Canadian team is known to have been a carrier or to have had the disease, and none of the opposing Eastney team contracted cerebro-spinal fever. Swabs from the throats of the Eastney team sent

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to Greenwich were found to be negative by Fleet-Surgeon P. W. Bassett-Smith, C.B. The Canadian team slept in a separate room with some sergeants, none of whom had cerebro-spinal fever, and for the most part kept to themselves. They were, however, shown round Portsmouth by a member of the Eastney team, who was a friend of the private who first contracted the disease and was also in daily contact with two men who went down with it on January 20. It was impossible to trace this line of infection any further. If any connexion is to be maintained between the Canadian and the Eastney epidemics it must be assumed that there were at least two undetected carriers, one among the Canadian team, who transferred the infection to a member of the Eastney team—probably the one who showed them round and was a friend of the private who first manifested the disease. On the other hand, the almost simultaneous outbreak of cases in other parts of the country and the weakness of the assumption of two hypothetical carriers make it probable that the epidemic was due to some undetected chronic carrier, and that the Canadians cannot be held responsible for the infection.

There was no evidence of overcrowding in the barracks, which, together with the School of Music, has an individual cubic space of 560 ft.; at this time all the rooms, except one, from which cases of cerebro-spinal fever came were below their normal complement.

Influenza and catarrh were severe in January; the total of such entries for the weeks ending January 16, 23, 30, during which there were 6 cases of cerebro-spinal fever, numbered 52 and 56, as compared with 36 and 41 for the whole of February, during which there was 1 case only of cerebro-spinal fever, and 22 and 41 in March, during which there were 3 cases of cerebro-spinal fever. These catarrhal conditions, by facilitating infection of the throat by meningococci, and so the existence of carriers, might favour an outbreak of the disease.

Investigation of the places visited by the men during Christmas leave did not show any evidence that the disease was contracted elsewhere.

Of the 12 cases there were 6 in January (5 occurring between January 15 and 20), 1 in February, 3 in March, and 2 in May. Of the 6 cases in January, 5 died, whereas of the 6 subsequent cases 1 only proved fatal.

The infection was traced in 5 out of the 12 cases. The second and fourth were infected from the first case; the fifth was infected from the third case; the tenth was in the sick bay with the ninth case and showed symptoms of cerebro-spinal fever three days later; the eleventh case probably contracted the disease in Birmingham.

Of the 12 cases, 7 were under 20 years of age with 3 deaths, 2 between 20 and 29 with 2 deaths, 2 between 30 and 39 with no deaths, and 1, aged 42, fatal. The average age of all the cases was 23·2 years; of the fatal cases, 24 years; and of the recoveries, 22·2 years.

Forty close contacts were examined and all found to be negative.

*Royal Marine Light Infantry Barracks, Forton.*—Four cases of cerebro-spinal fever were reported from this depot, but in none of them did the infection originate in the barracks. In January, two occurred in privates, who had quite recently (three and five days) been drafted from Deal, and almost certainly brought the disease with them. A quartermaster who worked in the barracks contracted the disease on March 9; he lived in Gosport, and cases of the disease occurred at that time in the immediate



neighbourhood of his house, and on March 11 his son was attacked with a rash and a temperature of 105° F. The fourth case was that of a man who, though nominally in the barracks, had been lent to the anti-aircraft guard in Weevil's Yard, and had not been in the barracks for some months. He slept in a crowded and ill-ventilated room in Weevil's Yard, and four days before the onset of cerebro-spinal fever returned from leave at Farnham, Surrey, where there were instances of cerebro-spinal fever among the troops.

It is suggestive that there was very little influenza, catarrh, sore throat, or tonsillitis in the barracks. From January 1 to May 1 there were 27 cases of influenza, 63 of catarrh, 36 of tonsillitis, and 4 of sore throat. There was no overcrowding in the early part of this year.

Out of 20 contacts 1 was found to be positive (Dudding).

*Isolated cases* were sent into the Royal Naval Hospital, Haslar, from the "Vernon," the "Excellent," and the "Fisgard." In none of these was the source of infection traced. The contacts were all negative.

#### ROYAL NAVAL BARRACKS, CHATHAM.

In the spring of 1914, two cases occurred (on March 2 and April 22) among the stokers in the "Pembroke." In August, 1914, the cubic space fell to 210 ft. per man. The first case of cerebro-spinal fever to occur during the War was a stoker in the "Pembroke," on October 29, and the third, on January 15, was in the same ship; the occurrence of cases in the "Pembroke" raises the possibility of a chronic carrier in that vessel, though the intervals are long. The second case arose on January 10, and the source of infection was not traced. The fourth case occurred on January 27 and was followed by 14 cases (9 in February) at short intervals up to March 17, so as to suggest infection from within the establishment, and more than half of these cases were traced to carriers, or to infection from previous cases. After this date 3 isolated cases occurred; 1 in the "Pembroke" was not traced, the other 2 probably contracted the disease outside, making 21 in all, with an average age of 26 years. Eleven of the 21 cases were in recruits, many of whom had recently joined; their average age was 21 years, and their duration of service twenty-four days (7 having less than twenty days' service, and 1 as long as eighty-eight days). Five had been recently vaccinated, 2 had shortly before the onset received a blow on the head, and 2 others had recently had scarlet fever—factors which, by reducing resistance, would favour infection. Between February 1 and March 17 there were 5 cases among the engine-room artificers. One hundred and thirty of these men were then examined; 30 were found to have nasal or faucial catarrh, and from among these 3 carriers were isolated. The mess was then divided into two, so as to give more air space, and after this there were no more cases among the engine-room artificers.

Ninety-two contacts were sent to the Royal Naval Hospital, Chatham, and 12 carriers were isolated. One of the carriers developed the disease while isolated and died. Of the 21 cases, 5 were definitely traced to healthy carriers by Deputy Surgeon-General C. J. Mansfield, M.V.O. All these 21 cases were transferred to the Royal Naval Hospital, Chatham, and 16 died, or 76 per cent. As the mortality rises with each decade up to 50, it might be assumed that this high mortality was due

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to the fact that 10 of the patients were over 30 years of age. But this was not so in this instance, for of the 11 patients under 30 years of age 8 died, as against 8 deaths among the 10 patients over that age. In addition, 3 cases from other sources (Shotley 1, the "Biarritz" 1, H.M. Dockyard 1) were treated at the Royal Naval Hospital, Chatham.

### CASES OF INFLUENZA, CATARRH, SORE THROAT AND TONSILLITIS FROM JANUARY 1 TO JUNE 30, 1915, AT THE ROYAL NAVAL BARRACKS, CHATHAM.

Disease		January	February	March	April	May	June
Influenza	..	109	101	74	96	45	13
Catarrh	..	154	204	111	103	72	37
Sore throat	..	90	30	29	19	16	14
Tonsillitis	..	40	78	136	88	68	61
		<hr/> 393	<hr/> 413	<hr/> 350	<hr/> 306	<hr/> 201	<hr/> 125

The maximum incidence of cases of cerebro-spinal fever (9) and of catarrhal affections of the throat (413) occurred in February, and the large number of catarrhal affections (393) in January might be thought to have favoured the carrier state and so to have been instrumental in leading to the comparatively large number of cases of cerebro-spinal fever in the following month. The incidence of cerebro-spinal fever (5) and of catarrhal affections (350) in March corresponded with the observation that three cases of the former appeared to be due to infection in the barracks (two by the same carrier). In April, although the number of catarrhal cases was not much less (306), the activity of meningococcic infection in the barracks had ceased, the only case of cerebro-spinal fever having contracted the disease in West Ham.

The direction of the wind and the day and night temperatures from January 1 to April 30 were examined in relation to the incidence of cerebro-spinal fever. In January the wind was mainly west or south-west for the first half of the month, and north and north-east in the second half of the month; two cases occurred in the first half and one in the second half. The average daily temperature was 40·8° F. February, during which there were 9 cases, was cold (average temperature 38° F.), although the wind was almost always south-west. In March there were 5 cases, all before March 17, and up to this date the wind was more often west or south-west than north or east. In the second half of the month there was rather more north and east wind than in the first half. The average temperature for the first seventeen days and for the last fourteen days was, in each case, 42° F. In April there was one case of cerebro-spinal fever (on April 5). The direction of the wind was on the same lines as in January, but the average daily temperature was 49° F.

So far, therefore, the occurrence of cerebro-spinal fever would appear to be associated much more with west and south-west winds than with east and north-east winds; but examination of the direction of the wind on the three days preceding the occurrence of cases during January to April shows that in about half the cases south and west winds, and in the rest east and north winds, prevailed. No decided conclusion, therefore, is justified as to the influence of the direction of the wind on the incidence of the disease. The largest number of cases occurred in February, which had the lowest average daily temperature, namely 38° F.



## PLYMOUTH DISTRICT.

In the summer of 1914 there were 7 cases, 5 in the "Impregnable" and 2 in the "Powerful." Sporadic cases began to arise among the civilian population in January, the first naval case having occurred on December 22, when on leave.

Thirty cases are considered here; 27 were treated in the Royal Naval Hospital, Plymouth, and the remaining 3 went sick when on leave. A man from the "Ajax" was also treated in the Royal Naval Hospital, but is not included here. Of the 30 cases, 15 arose in the Royal Naval Barracks, 9 in the "Impregnable," 3 in the Royal Marine Light Infantry Barracks, 2 in the "Powerful," and 1 in the "Indus." One boy borne in the "Indus" was in the Royal Naval Barracks, and is therefore included under that heading. A boy who left the "Impregnable" on April 3, where there had not been cases since February 12, developed cerebro-spinal fever the next day at Portsmouth (*vide* "Portsmouth District," p. 13).

Two cases occurred in December, 1914 (on December 22 and 25); none in January; 17 in February, of which 8 were in the "Impregnable"; 3 in March; 6 in April; and 2 in the last two days of May. There was an interval of five weeks between the cases in April and those in May; there was a corresponding freedom from the disease among the military and civil population until the end of May, when there was a recrudescence.

Up to March 1 there were 19 cases with a mortality of 9, or 47·3 per cent., whereas among the 11 subsequent cases there were 2 deaths only. The total mortality of 11 out of 30 cases, or 36·7 per cent., is very low. This is probably related to the fact that 25 of the patients were under 20 years of age and that none were over 30, for though the disease specially attacks the young, the mortality increases with age (*vide* p. 8). The average age of the 30 cases was 18 years (of 19 recoveries 17·7 and of fatalities 18·3 years). Out of the 30 cases the source of infection was traced in 11.

Overcrowding occurred at the Royal Naval Barracks, in the "Impregnable," and in the "Powerful."

In December, 1914, in which cases occurred on the 22nd and 25th, the wind was south-west for the first nine days, then easterly until the 14th, and northerly on the 22nd, 23rd, 24th. Although not convincing, the occurrence of east and northerly winds before the onset of the disease is suggestive. In January, in which there were no cases, the wind was easterly or north-east from the 21st to the 29th, and thus preceded the outbreak of 17 cases of cerebro-spinal fever in February, during which the wind was mainly south-west. In March there were 3 cases only and there was a good deal of east and north wind, especially from the 22nd to the 29th. On April 5, a man who had been in close contact with a case, and had had catarrh for some days, showed meningeal symptoms; possibly the cold winds at the end of March may have been instrumental in his illness. For the first seven days of April the wind was south-west, and for the remainder of the month mainly northerly; cases of the disease occurred on the 14th, 21st, and 26th. There was therefore some evidence that the disease is prone to follow in the wake of east and north winds.

The comparison of the average daily temperature with the monthly

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incidence of cerebro-spinal fever did not show any striking correspondence between a low temperature and the incidence of the disease.

Month		Average daily temperature	Cases of cerebro-spinal fever	
1914	December	.. 44.4° F.	..	2
1915	January..	.. 45.0°	..	0
	February	.. 43.8°	..	17
	March ..	.. 43.8°	..	3
	April ..	.. 48.5°	..	5

Fleet-Surgeon H. C. Whiteside found that out of 402 close contacts 97, or 27 per cent., were carriers. Two of these carriers developed the disease. Remote contacts were also examined; out of 389 from the Royal Naval Barracks (where there were 15 cases) 45, or 11.6 per cent., were carriers; out of 667 from the Youths' Training Establishments 29, or 4.35 per cent., were carriers. Of the 1,458 contacts, close and remote, 171, or 12 per cent., carriers were found.<sup>1</sup> Close contacts were persons who had slept in close proximity to a patient, or were in the same mess, or otherwise brought into close relationship with him. Remote contacts were all those who slept in the same room or were in the same training class as a patient.

*The Royal Naval Barracks, Devonport*, contain five blocks (A, B, C, D, E); A block contains three rooms with a normal cubic capacity per man for messing accommodation of 293 cubic feet, and for sleeping accommodation 354 cubic feet. B block contains four rooms with corresponding cubic spaces of 302 and 355 cubic feet. C, D, and E blocks each contain four rooms with corresponding cubic spaces of 216 and 274 cubic feet. It is noteworthy that of the 15 cases there were 12 in blocks D and E, and only one in B block. This is compatible with the view that deficient cubic space favours the spread of the disease. Further, in February, when there was overcrowding in the barracks, the largest number of cases (6) in any one month occurred. Out of the 15 cases 1 had been in the Service over a year, the other 14 were recent recruits with an average service of thirty days.

The figures given below show that the incidence of catarrhal affections (influenza, catarrh, sore throat, and tonsillitis) in the barracks was highest in January and February; and that, though the maximal incidences of the catarrhal affections and of cerebro-spinal fever both occurred in February, the correspondence in other months was far from exact. It might be thought that the high incidence of catarrhal affections in January, during which month there were no cases of cerebro-spinal fever, was instrumental, by favouring the carrier state in the occurrence of 6 cases beginning on February 12.

Month		Cases of catarrhal affections		Cases of cerebro-spinal fever	
1914—	December	..	195	..	2
1915—	January	..	355	..	0
	February	..	364	..	6
	March	..	210	..	2
	April	..	124	..	4
	May ..	..	100	..	1
	June ..	..	97	..	0

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<sup>1</sup> Fleet-Surgeon H. C. Whiteside dealt with the bacteriological examination and treatment of contacts at the Royal Naval Hospital, Plymouth, in the *JOURNAL OF THE ROYAL NAVAL MEDICAL SERVICE*, 1915, vol. i, No. 3, pp. 248-254.



Two cases occurred in December in men who were in the same room and came from Ashburton. The first, who had not been home for some time, was taken ill in the barracks on December 22, and infected the second, who went sick when on Christmas leave on December 25. In January there were no cases. The next case was on February 12 and was followed by cases on the 14th, 18th, 23rd (two cases), and 26th, and on March 4. Then, after an interval of seventeen days, a man who had come to Plymouth the day before was taken ill on March 21, and obviously brought the infection with him; he travelled down with a man who, after attending the sick quarters for some days, manifested meningeal symptoms on April 5. In the meanwhile an untraced case occurred on March 31. Cases cropped up on April 14, 21, and 26. Then there was an interval of thirty-three days until the last case occurred on May 29. It is noteworthy that both in the civil and military population of the district there was a corresponding freedom from the disease with a recrudescence at the end of May.

Fleet-Surgeon H. C. Whiteside examined 78 close contacts and found 15, or 19·2 per cent., positive; and 389 remote contacts with 45, or 11·6 per cent., positive—a high percentage.

The "*Impregnable*" establishment consists of three ships, and has no official complement; the number of boys varies greatly with recruiting. The following estimate of the cubic space is provided by Fleet-Surgeon F. Fedarb. "*Impregnable I*" has a cubic space in the sleeping compartments varying from 175 to 291, and averaging 244 cubic feet per boy; "*Impregnable II*" has a cubic space in the sleeping compartments varying from 167 to 258, and averaging 203 cubic feet per boy; "*Impregnable III*" has a cubic space in the sleeping compartments varying from 210 to 497, and averaging 313 cubic feet per boy. There is, therefore, very definite overcrowding in all three ships. I inspected the ships by day on July 9; and the boys' class-room in "*Impregnable II*," which has, I understand, been already condemned, was obviously stuffy. I also went over the "*Impregnable*" that night at 10 p.m. with the expectation of finding the air in the sleeping compartments offensive. It was a quiet fine night and the ports were open; the only place in which the air seemed offensive was the boys' class-room, which is used as a sleeping compartment for twenty-eight boys, with a cubic space of 183 ft. per boy, but on that night held twenty boys with a cubic space of 256 ft. per boy.

In the summer of 1914 there were 5 cases of cerebro-spinal fever in the "*Impregnable*." Between February 8 and 12, 1915, 5 cases of the disease occurred, 4 being from "*Impregnable III*," though from different messes, and one from "*Impregnable II*." On February 13 and 14, contacts to the number of 123 were removed to the Royal Naval Hospital, Devonport, and 31 carriers were detected. The carriers were detained and 2 of them developed cerebro-spinal fever on February 15 and 24. On February 19, a boy from "*Impregnable III*" went on leave to Torquay and developed the disease. The outbreak then stopped, and it may be concluded that the isolation of the contacts played a part in this, especially as two of them subsequently went down with the disease while in hospital. On April 3 a boy was drafted from "*Impregnable III*," where he was in a mess which had not contributed any case of cerebro-spinal fever, to the Boys' Training Establishment, Royal Naval

Barracks, Portsmouth. He developed the disease the next day. On April 24, two boys from a mess in which a case of cerebro-spinal fever occurred on February 11 were transferred from "Impregnable III" to the Royal Naval Barracks, Portsmouth. They developed the disease on May 1 and 8 respectively. The last case occurred on May 30, in "Impregnable I," where no cases of cerebro-spinal fever had previously arisen. He joined the "Powerful" on March 23, was transferred on April 3 (the same day as the boy referred to above) to the Royal Naval Barracks, Portsmouth, where he was in the same room and in an adjacent mess to the two boys drafted there on April 24 from "Impregnable III." He was discharged to the "Impregnable" on May 21.

February, during which the outbreak of 8 cases of cerebro-spinal fever occurred, had the highest incidence of catarrhal affections (catarrh, sore throat, tonsillitis and influenza).

Month			Cases of catarrhal affections		Cases of cerebro-spinal fever	
1914	December	..	..	27	..	0
1915	January	..	..	75	..	0
	February	..	..	88	..	8
	March ..	..	..	42	..	0
	April ..	..	..	54	..	1*
	May ..	..	..	47	..	3†
	June ..	..	..	60	..	0

\* This boy was drafted from the "Impregnable" on April 3, and developed cerebro-spinal fever next day at Portsmouth.

† Two of the boys, drafted seven and fourteen days previously from the "Impregnable," developed the disease at Portsmouth. The other boy was drafted to the "Impregnable" from Portsmouth eight days before he went sick.

The "Powerful" establishment consists of two ships—"Powerful" I and II. The boys are distributed in these two ships according to their work. "Powerful II" is stated not to be overcrowded, but "Powerful I" is certainly overcrowded; on April 10, when the two cases of cerebro-spinal fever occurred, there was a cubic space of only 225 ft. in the sleeping compartments. The hammocks are within 18 in. of each other, and the casements, in which classes of about twenty boys are held, have a cubic space of from 1,690 to 1,705 ft., or 85 cubic feet per boy. Catarrhal affections are common, as is seen by the following table for the first six months of 1915, furnished by Fleet-Surgeon Oswald Rees :—

Month			Catarrh	Sore throat	Tonsillitis	Total cases	Total of days' sickness
January	..	..	31	42	18	91	377
February	..	..	37	51	35	123	697
March	..	..	41	57	38	136	677
April	..	..	19	30	19	68	370
May	..	..	16	11	40	67	320
June	..	..	25	18	26	69	380
			169	209	176	554	2,821

Practically all the cases of sore throat and tonsillitis have been isolated in casements, and this would tend to prevent their spread. This isolation has not been adopted with the cases of catarrh.

In 1914 two cases of cerebro-spinal fever occurred in the "Powerful." In 1915 two cases occurred on April 10 in the same mess in "Power-



ful I." Fifty-five contacts were examined, and fifteen carriers, or 27 per cent., detected. In this mess a carrier was found who had had "influenza in a severe form" at Liverpool fifty-six days previously, and was probably the source of infection. After this no further cases occurred. With conditions so favourable to an epidemic, the arrest of the disease is striking and remarkable.

*Royal Marine Light Infantry Barracks, Devonport.*—Three cases occurred in these barracks, on February 3, 16, and 24. The men were not friends, and they slept and ate in different rooms. Two of them belonged to the same company and, though in the same house, were not in rooms that opened on to the same passage-way. Fleet-Surgeon J. Andrews, R.N., could not discover any contact between the men, or that they had visited infected houses, but he was inclined to the view that the infection might have been acquired in picture halls which they visited. There were, however, comparatively few cases of cerebro-spinal fever in the civilian population. Dr. O. Hall, the Medical Officer of Health for Plymouth, informs me that during the first six months of this year, seventeen civilian cases of cerebro-spinal fever were notified. Adequate precautions were taken at the barracks and no more cases occurred.

"*Indus*."—Two cases occurred in boy artificers borne in the "*Indus*," but one of them had been billeted in the Royal Naval Barracks until two or three days before the onset of the disease on February 23, and should therefore be considered as belonging to the Royal Naval Barracks. The other case had been billeted in the Royal Naval Barracks until three weeks before the onset on March 4. Of 18 contacts from the "*Indus*," 3, or 16·6 per cent., were found to be carriers.

#### CRYSTAL PALACE.

At the Crystal Palace there were, between January 16 and the end of July, 33 cases of cerebro-spinal fever, with a mortality of 21, or 63·6 per cent. Up to March 1 there were 17 cases, of which 14, or 82 per cent., were fatal; after March 1 there were 16 cases, of which 6, or 37·5 per cent., were fatal. A falling mortality in the course of epidemics is generally recognized, but it should be pointed out that the cleanliness and ventilation of the men's quarters were much improved in the later part of the outbreak. The cases were mainly among young recruits; the average age of all the cases was 23 years; 16 were under 29 years of age, and 27 under the age of 25. Of 16 under 20 years of age, 8 proved fatal: of the 27 under 25 there were 16 deaths, while of 6 cases over the age of 25 years, 5 died. While, therefore, the majority of the cases were young patients, the mortality ratio increased steadily with the age.

The first case occurred on January 16 in a boy who returned from Christmas leave (December 30 to January 6); he had been to Aberdeen, where there had been a case of cerebro-spinal fever in a Canadian, fatal, on December 5, but none since; he may also have visited Glasgow, where cases had occurred. The second case, on January 20, was not traced; then after an interval 2 occurred on January 29 and 1 on February 1, 2, and 3. Fifteen contacts from these cases gave uniformly negative results. After an interval of four days the ninth case occurred in the Officers' Training Corps on February 7. Two days later a man who



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slept in the same dormitory as Case 7 developed the disease, and 1 of his 4 contacts was found to be a carrier. Between February 10 and 14 4 occurred in the Public Schools Battalion, and among the contacts of 1 case that had had catarrh since January 28, 3 carriers were found. Some weeks later, 30 men from this battalion were found to be negative bacteriologically. Two occurred among the Officers' Training Corps on February 14 and March 1, their contacts being negative. Isolated cases occurred on February 23 and March 1. Then on March 14 to 15, 3 arose in B Company, 1st Battalion, the contacts of 1 case giving 2 carriers, one of whom was positive for three weeks. Isolated cases occurred on March 15 and 16, and then there was a lull till March 23, when a sporadic case appeared. On March 27 there were 2 cases in the same company. Five occurred in the first thirteen days of April, and then there was none until July 8, when a man who had been in contact with Case 26, who had returned to duty, went sick. A fresh bacteriological examination of faucial swabs from Case 26 proved negative.

Altogether the infection was traced in 8 cases out of the 33, or 24 per cent. The close proximity of the Crystal Palace to London no doubt favoured the introduction of the disease from outside infection.

The contacts, 122 in number, were examined by Fleet-Surgeon P. W. Bassett-Smith, C.B., who found 12, or 9.9 per cent., positive.

### DEAL.

The barracks consist of three groups of buildings some distance apart and with separate blocks in each. An increase in the number of men was naturally accompanied by an increase in the sick list; thus in the January to March quarter of 1914 there were 115 cases of catarrh, as compared with 292 in the corresponding quarter in 1915, but while the number of men was about doubled the cases of catarrh were nearly trebled. Overcrowding therefore increased the incidence of catarrh, which would favour the spread of meningococcic infection. For some years at least there had not been any case of cerebro-spinal fever in the barracks.

The origin of the outbreak was not discovered. There were no civilian cases in Deal or Walmer, but there were some at Sandwich, eight miles off. A man who went sick on February 1 had spent his Christmas leave (December 23 to 28) at Salisbury (town), where, the Medical Officer of Health (Dr. Fison) informs me, the first case of cerebro-spinal fever occurred on December 13, in a nurse (engaged to a Canadian officer) in the hospital, the second on December 20, and the third on December 23. Analysis of the rooms, squads, and companies of the cases showed a wide distribution of the disease, and did not explain how the infection spread; but as the canteen, the recreation and billiard rooms are common ground, contact may have occurred there.

The outbreak in the barracks of what was subsequently (February 5) determined to be cerebro-spinal fever really began on January 20, and fresh cases followed almost daily until February 13, when there was an interval of twelve days; 2 cases then occurred on February 25 and 27; and then after another interval 3 cases on March 10, 12, 14. After this there were no more cases. The cessation of the epidemic may possibly have been connected with the fact that all the men using the warm swimming bath sprayed their throats before bathing.



The Deal Marine Depot was apparently responsible for 25 cases; 17 were treated in the infirmary and 3 developed at Maidstone among the 1,000 men who marched there from Deal. The 20 cases are considered here. In addition 2 occurred at the Royal Marine Light Infantry Barracks, Gosport, on January 19 and 24, within a few days (five and three respectively) of leaving Deal (*vide* Report on Portsmouth district), and 3 occurred among the Deal Battalion shortly after their arrival at Blandford (*vide* Report on Blandford).

Of the 20 cases, 6 proved fatal. Out of 17 before March 1, there were 6 deaths, whereas the 3 cases after that date recovered. This percentage of deaths (30) is the lowest in any of the groups of cases, though that of 36·7 per cent. in the Plymouth district approximates to it. All the patients were under 20 years of age, the average age being 17·6 years (for 14 recoveries 17·8 years, and for 6 fatalities 17·2 years). The remarkably low death-rate at Deal is probably due to the fact that all the cases were under 20, for, as shown elsewhere, the mortality is less under 20 years of age than at any other period of life; thus the mortality (45) of all the cases in the Navy (103) under 20 years of age was 43·7 per cent., as compared with 62·8, 76, 77, and 66 per cent. for four succeeding decades.

The disease did not spread to non-commissioned officers or to the children of married men living in barracks, but the schoolroom for these children was no longer used at other times by the men.

One hundred and thirty-two contacts were examined; of these, 97 were close contacts with 16 positive results, and 35 remote contacts, all negative. The percentage of positive results among the 132 contacts was 12·1 (E. A. Shaw).

During the first fifteen days of January the wind was with one exception west or south-west; on January 16 and 17 north-west winds preceded the outbreak of the epidemic; from January 19 to 21 the wind was west, and for the rest of the month mainly east or north-west. During February, in which 10 cases of cerebro-spinal fever occurred, the wind was south or south-west on twenty days, and north-west on the remaining eight days. But 8 of the cases occurred in the first thirteen days, that is, after the north-west winds at the end of January; the other 2 cases occurred directly after the north-west winds on February 23 to 25. In March, north-east and north-west winds on the 7th, 8th, and 9th preceded the appearance of the last 3 cases of the disease on March 10, 12, 14. The occurrence of north and east winds was thus followed by the incidence of cerebro-spinal fever cases.

The following shows a comparison between the average daily temperature and the monthly incidence of cases of cerebro-spinal fever:—

	Average daily temperature			Cases of cerebro-spinal fever		
January	..	..	44·4° F.	..	..	7
February	..	..	46°	..	..	10
March	..	..	48°	..	..	3

#### BLANDFORD.

The camp was opened in January, 1915, and the first case of cerebro-spinal fever occurred on February 1 in the Deal Battalion. On February 3 two cases occurred, one in the Deal Battalion and the other in the

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"Collingwood" Battalion which was in the Blandford Camp. On February 4 another man in the Deal Battalion went sick. After an interval of a fortnight a man in the "Howe" Battalion manifested the disease. The sixth and last case—a sporadic one—occurred on April 9 in the "Benbow" Battalion.

At the Marine Depot at Deal an outbreak of cerebro-spinal fever really began on January 20, though its nature was not absolutely settled until February 5. In the meanwhile 1,000 men marched on January 24 from Deal *en route* for the Blandford Camp; they stopped the first night at Littlebourne, the second at Charing, the third at Bearsted, and the following morning (January 27) entrained from Maidstone, where three men went down with the disease. On its arrival in Dorset the battalion was isolated for three weeks at Durweston and Stourpaine, some miles from the main camp at Blandford; the men were billeted in cottages, and two of them developed cerebro-spinal fever; in one instance the infection spread from one of these men to a girl in the same cottage. Four other civilian cases occurred.

Of the six cases four died. Four cases were under 20, one was 24, and one aged 34. The average age of all the cases was 22 years, of the fatal cases 22·7 years, and of the two recoveries 21 years. The cases were transferred for treatment to the Royal Naval Hospital, Portland, where 58 contacts were examined; 4 were positive on the first examination, and negative afterwards. One sick berth attendant was positive on two occasions (Shand and Hitch).

Meteorological records were not kept at Blandford. January and February were both very wet.

### SHOTLEY BARRACKS.

There are fifty-two dormitories, each with a cubic space to each boy of 476·6 ft. Some of these dormitories are usually empty in preparation for drafts which are constantly arriving. During the War, each dormitory has had an individual cubic space of 400 ft. The beds are now arranged with the head and foot alternately. In one dormitory (No. 17) there have been as many as sixty-seven occupants, with a cubic space of 356 ft., but no case of cerebro-spinal fever occurred in it. The boys do not live or eat during the day in these dormitories. The "gymnasium dormitory," which contains 105 boys, who live, eat, and sleep in it, is used for isolating drafts from barracks, usually for ten days. The class-rooms, which take classes of about twenty-five each, appeared to be well ventilated, with, in most instances, a cross draught. There does not, therefore, seem to be any reason to consider that overcrowding has been responsible for the cases.

The seven cases of cerebro-spinal fever occurred in newly joined boys, on an average, twenty-five days after entering the service; the shortest period (two cases) was seventeen days and the longest forty-two days after joining. A case of cerebro-spinal fever in a man aged 28 was treated in the hospital, but is not included here; he came from the "Queen Victoria" and had not been ashore for one month.

The first case occurred on January 23 and was transferred to the Royal Naval Hospital, Chatham, proving fatal on March 20. After an interval of five weeks three cases appeared between February 28 and



March 4; two of these cases (onset February 28, March 4) joined the same day (February 13) from different parts of the country and slept for one night only in the same dormitory. In the home of the other boy (onset March 1), who joined the barracks on February 8, some soldiers had been billeted. The other three cases occurred on April 26, May 29, and June 10. Analysis of the dormitories and classes of the seven cases did not reveal any evidence of the spread of infection. Three of the cases had been recently vaccinated, the interval between vaccination and the onset of cerebro-spinal fever being twelve, seventeen, and seventeen days respectively.

In the Felixstowe district there were thirty cases of cerebro-spinal fever between January 21 and July 6, and eighteen before February 28; and no cases between April 23 and June 27. It is therefore improbable that the last two cases at Shotley (on May 29, June 10) were imported from the Felixstowe district. There was one case of the disease in 1914, on October 28, in a child aged 1 year 10 months. The incidence at Shotley of catarrh and tonsillitis during the first half of 1915 was much higher than in the corresponding period of 1914. Thus from January to March, 1915, there were 203 cases of catarrh and 33 of tonsillitis as compared with 35 of catarrh and 47 of tonsillitis in January to March, 1914. From April to June, 1915, there were 99 cases of catarrh and 139 of tonsillitis as compared with 52 and 69 in the April to June quarter of 1914. In the last quarter of 1914 (no cases of cerebro-spinal fever) there were 18 cases of catarrh and 86 of tonsillitis as compared with 203 and 33 in the first quarter of 1915 (4 cases of cerebro-spinal fever). A high incidence of catarrh therefore coincides with the occurrence of cerebro-spinal fever. From the monthly return of catarrh and tonsillitis it is seen that the high incidence of catarrh (85) in February preceded the small outburst of three cases of cerebro-spinal fever, February 28 to March 4.

1915			Catarrh			Tonsillitis
January	..	..	58	..	..	10
February	..	..	85	..	..	7
March	..	..	60	..	..	16
April	..	..	62	..	..	37
May	..	..	25	..	..	52
June	..	..	12	..	..	50

Contacts were examined by Staff-Surgeon Dudley at the Royal Naval Hospital, Chatham, and some were examined by Dr. Sheffield Neave, who was doing bacteriological work at Ipswich; the latter arrangement obviated the risk that the swabs might fail to reveal the meningococcus because of the delay in conveying them to Chatham. One positive contact only was found.

#### CASES IN SEA-GOING SHIPS.

Twelve cases occurred in sea-going ships, and in one vessel (the "Biarritz") only was there more than one case, a most satisfactory result. The cases occurred in the "Changuinola" (January 20), "King George V" (February 19), the "Implacable" (February 23), the "Ajax" (March 11), the "Queen Victoria" (April 4), the "Norma" (April 22), the "Bellerophon" (April 23), the "New Zealand" (April 25), the "St. Vincent".

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(May 9), the "Biarritz" (May 19), the "Liverpool" (May 25), and the "Biarritz" (July 19). The probable source of infection was traced in 3 cases. The average age of the 12 cases was 26 years, of the 8 fatal cases 28·5 years, and of the 4 recoveries 21·5 years.

### NAVAL SICK QUARTERS, WICKLOW.

One fatal case of cerebro-spinal fever occurred in a chief petty officer, who contracted the disease from a carrier from Cork.

### "AKBAR" ESTABLISHMENT.

The "Akbar" establishment consists of three hulks, moored side by side. The men on board are civilians engaged in engineering work. In two hulks the ventilation is deficient, but especially in one, the lower deck of which only provides an individual cubic space of 220 ft. for men messing and sleeping. In the other hulk the arrangements appear to be adequate. Four cases of cerebro-spinal fever occurred in the "Akbar" establishment on March 26, April 11, April 22, and June 5. They were all treated at the Dingwall Hospital and recovered.

For the most willing and courteous help in this investigation, I offer my sincere thanks to the medical officers of the hospitals, barracks and establishments which it has been my privilege to visit; in addition to those incidentally mentioned above I must refer to the following: Deputy Surgeons-General H. W. G. Doyne, V. G. Thorpe; Fleet-Surgeons M. Rodd, J. A. Campbell, C. L. W. Bunton, W. J. Colborne, J. C. Ferguson, C. Strickland, F. W. Parker, R. Hickson, R. Hill, C.V.O., W. H. S. Stalkartt; Staff-Surgeon B. Pick; Surgeons C. H. Gimlette, J. C. Baggs, J. A. Fairer; and to Dr. J. J. Jervis (Croydon Borough Hospital). Dr. F. Ford Caiger (S.W. Fever Hospital), Dr. Mearns Fraser (M.O.H., Portsmouth), Dr. Linton (M.O.H., Tunbridge Wells), Dr. A. K. Chalmers (M.O.H., Glasgow), Professor M. Hay (M.O.H., Aberdeen), Dr. J. Robertson (M.O.H., Birmingham), Dr. Dunlop (M.O.H., Torquay), Dr. G. I. P. Stewart (M.O.H., East Suffolk), Dr. Conford (M.O.H., Felixstowe), Colonel Caldwell and Lieut. M. Culpin, R.A.M.C. (Alexandra Hospital, Cosham).

### (III) SUMMARY OF THE RARER MANIFESTATIONS AND COMPLICATIONS.

More or less complete notes of 163 out of the 170 cases were obtained and abstracted. But as comparatively little interest would attach to an analysis of all the constant or common symptoms, such as fever, headache, rigidity of the neck, retraction of the head, Kernig's sign, delirium, and vomiting, the rarer symptoms and complications will be briefly mentioned here. But before summarizing the rarer symptoms it may perhaps be permissible to refer to the rashes, which are rare in sporadic cases, at least as far as



my experience goes, and were striking in this epidemic. Rashes were noted in 102 out of 163 cases, or in 62·6 per cent. In a few of these 102 cases the rash was papular, but in the rest it was petechial or purpuric. Fifty-two cases died and 50 recovered. The rashes with large hæmorrhages were specially fatal. The rash came out early in the septicæmic stage, being comparable with the rose spots of enteric, and was commonly present when the patient was first seen; in some instances a hæmorrhagic rash recurred before death. Herpes was noted in 35 cases; in 18 of these there was also a rash; in 5 the rash and the herpes occurred together. In 13 the herpes followed the rash, usually after an interval of four days. In a few instances the herpes extended to the ears, or was very extensive. Serum rashes were mentioned in the notes of 19 cases, but very likely were commoner than this, and in a few instances were accompanied by pains in the joints.

Strabismus was recorded in 21 cases; it was often transient or intermittent, but one man was invalided out of the Service for persistent diplopia. Of the 21 cases, 12 proved fatal.

Photophobia was noted in 21 cases, and conjunctivitis in 9, in 1 of which double hypopyon and blindness resulted. Optic neuritis was reported in 4 only, but the number of cases examined was not large. Nystagmus was observed in 5 cases, and ptosis in 7 (6 fatal). Definite paralysis was noted in 16 cases, hemiplegia being the most frequent (in 8 cases), then facial paralysis without hemiplegia (in 5 cases); bulbar paralysis, palatal, and pharyngeal paralysis were noted in 1 case each, but the last two paralysees may easily have escaped observation in many cases. An extensor plantar response was noted in 11 cases, and was sometimes double, sometimes unilateral. Ankle clonus, opisthotonos, and general rigidity were recorded in a few cases. Deafness was prominent in 11 cases (2 due to otitis). Pericarditis with friction and effusion was noted in one case that recovered, and pericarditis was found in 3 other cases after death. Synovitis occurred in 8 cases, 6 of which recovered; in 2 of these cases the meningeal symptoms were absent or very slight, and it has been stated that the prognosis is good in cases with articular manifestations, because the joints receive the meningococci and so divert them from the meninges. The synovitis was usually multiple and transient, and never suppurated. In addition, 1 case had a synovial effusion after serum. Otitis was observed in 4 cases, 1 of which was associated with suppurative parotitis. In 2 cases (1 fatal) epididymitis occurred. Hæmaturia was noted in 1 case, and melæna in another. In

2 cases clinically presenting the features of pneumonia, meningococci were found in the cerebro-spinal fluid at the necropsy, which also showed pneumonia. In another case of pneumonia, also at Deal and fatal, meningococci were found in the cerebro-spinal fluid obtained by lumbar puncture. These cases are important as showing that meningococcic infection may co-exist with pneumonia, for pneumonia may produce meningismus with a clear and sterile cerebro-spinal fluid. In one case of cerebro-spinal fever at Chatham, aspiration pneumonia was found at the necropsy. In one case pleurisy without pneumonia was observed clinically (no necropsy), and in another case severe broncho-pneumonia with a patch of pleurisy was found after death.

#### (IV) SUMMARY OF THE RESULTS OF TREATMENT.

This summary is abstracted from the notes of 163 cases, 89, or 54·6 per cent., of which proved fatal. The prolonged and unsatisfactory cases naturally received more varied treatment than the fulminating cases, some of which died shortly after coming into hospital. As will be seen by the tabular statement, various forms and combinations of treatment were employed, and the most noticeable point is the failure of the generally approved intrathecal injection of anti-meningococcic serum.

Anti-meningococcic serum from various sources (Burroughs Wellcome and Co., the Lister Institute, Mulford (~~Flexner~~)), was employed.<sup>1</sup> In 105 cases the treatment consisted of lumbar puncture and intrathecal injection of the serum, either alone (62 cases) or with the addition of vaccines, soamin, or hexamine (43 cases). Of these 105 cases 64, or 61 per cent., died; and 41, or 39 per cent., recovered. Of the 62 cases treated by lumbar puncture and intrathecal injection of serum death occurred in 43, or 69·4 per cent., and recovery in 19, or 30·6 per cent.; whereas of 43 cases treated in addition by vaccines, soamin, or hexamine 20, or 46·5 per cent., were fatal, and 23, or 53·5 per cent., recovered. It is therefore obvious that the cases treated by the intrathecal injection of serum, and especially those in which this was the only specific treatment adopted, had a higher death-rate than that (54·6 per cent.) of the whole series of 163 cases. Flexner<sup>2</sup> has laid much

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<sup>1</sup> In one case at Deal, 10 c.c. of blood serum from a patient convalescent from the disease was injected intrathecally the day before death.

<sup>2</sup> Flexner, *Journ. Exper. Med.*, N.Y., 1913, vol. xvii, p. 553.



stress on the importance of injecting anti-meningococcic serum intrathecally as early as possible in the disease ; and in a table dealing with 1,211 cases he shows that when the serum is injected

	Cases	Deaths	Recoveries
<i>Anti-meningococcic serum—</i>		Per cent.	Per cent.
Intrathecally ... ..	105	64 or 61	41 or 39
Alone ... ..	62	43 „ 69·4	19 „ 30·6
Combined with vaccines, soamin, hexamine, or serum hypodermically	43	20 „ 46·5	23 „ 53·5
Combined with soamin ... ..	18	11 „ 61	7 „ 39
Combined with an auto-vaccine ...	11	2 „ 18·2	9 „ 81·8
Combined with hexamine... ..	7	5 „ 71·4	2 „ 28·6
Combined with serum hypodermically	7	2 „ 28·6	5 „ 71·4
Hypodermically ... ..	19	6 „ 31·6	13 „ 68·4
Alone ... ..	4	1	3
Combined with intrathecal injection of serum	7	2	5
Combined with auto-vaccine and intrathecal injection of serum	4	1	3
Combined with an auto-vaccine ...	3	2	1
Combined with soamin ... ..	1	0	1
<i>Autogenous vaccine</i> (never alone) ...	16	4 „ 25	12 „ 75
Combined with serum intrathecally ...	6	1	5
Combined with serum intrathecally and hypodermically	4	1	3
Combined with serum intrathecally and soamin	1	0	1
Combined with serum hypodermically	4	2	2
Combined with soamin ... ..	1	0	1
<i>Soamin</i> ... ..	43	19 „ 44	24 „ 56
Alone ... ..	21	7 „ 33·3	14 „ 66·7
Combined with serum intrathecally ...	18	11 „ 61	7 „ 39
Combined with serum intrathecally and hexamine	1	1	0
Combined with serum intrathecally and vaccine	1	1	0
Combined with serum hypodermically	1	0	1
Combined with an auto-vaccine ...	1	0	1
<i>Lumbar puncture</i> (alone) ... ..	13	4 „ 30·8	9 „ 69·2
<i>Symptomatic treatment</i> (only) ... ..	14	10 „ 71· <del>4</del>	4 „ 28·6

within the first three days the mortality-rate is 18 per cent., when between the fourth and seventh days 27·2 per cent., and when later than the seventh day 36·5 per cent. The following tabulation

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of 105 cases treated in the Royal Navy has been made on the same lines for comparison:—

	Cases	Deaths	Recoveries
1st to 3rd day ...	70	42 or 60 per cent.	28 or 40 per cent.
4th to 7th day ...	24	14 „ 58·3 „	10 „ 41·7 „
Later than 7th day	11	8 „ 72·7 „	3 „ 27·3 „

The failure of anti-meningococcic serum to reduce the mortality was therefore not due to its being given too late, for in 66·7 per cent. of the 105 cases it was administered within the first three days of the disease. The serum treatment, which was so successful in America (Flexner, Sophian), Belfast (Robb), and elsewhere, was given a thorough trial and proved most disappointing. In very few instances was there the critical improvement which is said to occur in about 30 per cent. of the cases that recover (Flexner<sup>1</sup>). Possibly the meningococci were “fast” to the action of the serum or were para-meningococci. In consequence of its apparent inertness intrathecal injection of serum was in the latter part of the epidemic largely replaced by or combined with other methods, such as the intramuscular injection of soamin. It is true that the mortality naturally diminishes towards the end of epidemics; and this may to some extent explain why, as shown by the tabular statement, the results of intrathecal injection of serum compare badly with those of almost all the other methods and combinations of methods. There is, for example, a remarkable contrast between the effects of intramuscular injections of soamin, (a) when given alone to 21 cases with a mortality of 33·3 per cent., and (b) when combined with intrathecal injection of serum in 18 cases, with a mortality of 61 per cent. It must be recognized that when dealing with small numbers fallacies easily creep in, but merely from these figures the addition of intrathecal injection of serum would appear to have coincided with an increase of mortality in the cases treated with soamin. The high mortality can hardly be explained by the suggestion that it was due to the bad effects of lumbar puncture, for in 13 cases in which lumbar puncture alone was employed there were 9, or 69 per cent., recoveries; and in 91 per cent. of the 163 cases lumbar puncture was performed, and in many cases repeatedly, to relieve symptoms referable to increased intrathecal pressure. Alarming symptoms directly after the intrathecal injection occurred in 2 cases only, thus showing that the gravity method of administration, which was not in vogue in the Royal Navy, is hardly necessary provided due care be taken.

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<sup>1</sup> Quoted by Heiman and Feldstein, “Meningococcus Meningitis,” 1913, p. 282.



Anti-meningococcic serum was given hypodermically in 20 cases, but as in 4 cases only was it the sole form of specific treatment employed, no conclusions as to its influence can be drawn.

An autogenous vaccine was given in 16 cases, mainly by Fleet-Surgeon H. C. Whiteside, R.N., at Plymouth, where the mortality (36·7 per cent.) was remarkably low. The cases to which auto-vaccines were given all received other specific remedies (in 11 cases intrathecal injections of serum), and showed the very low mortality of 25 per cent. But as the numbers are small this result—though a further stimulus to its more extended use—must not be insisted on.

As already mentioned, soamin appeared to give good results; its beneficial effect in the septicæmic stage of the disease was noticed by Staff-Surgeon B. S. Robson, R.N., at Haslar, and has also been mentioned by others.<sup>1</sup> In one case at Portland Hospital as much as 42 gr. of soamin were given. Optic atrophy was not noted in any instance.

Hexamine was given by the mouth in 7 cases in the hope that, as it is secreted into the cerebro-spinal fluid, it would exert a bactericidal action on the meningococci, but as it did not appear to have any effect clinically, it was soon abandoned.

Lumbar puncture, which is such an important means of diagnosis, was performed in 149 out of 163 cases, or in 91·4 per cent. In 38 cases lumbar puncture was done once only, but 14 of these cases died soon after they came under observation; 6 other cases, tapped once, died. Of 22 cases, tapped twice, 8 proved fatal, 2 being very acute; 3 tappings were done in 20 cases (9 deaths), 4 in 24 (15 deaths), 5 in 15 (9 deaths), 6 in 6 (3 deaths), 7 in 7 (4 deaths), 8 in 3 (2 deaths), 9 in 4 (all fatal), 11 in 5 (2 deaths), 13 in 1 (fatal), 15 in 1 (fatal), 16 in 1 (fatal), and 17 in 2 (both recoveries). Lumbar puncture appears to be a palliative rather than a curative remedy and to relieve for a time symptoms due to increased intrathecal pressure. In 13 cases, of which 4 proved fatal, it was the only form of treatment other than the ordinary symptomatic remedies employed.

In 14 cases, 10 of which proved fatal, symptomatic remedies only (such as morphine for pain) were given.

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<sup>1</sup> Batten, *Lancet*, London, 1915, vol. i, p. 966.

## (V) RECOMMENDATIONS AS TO THE PREVENTION (i) OF CEREBRO-SPINAL FEVER AND (ii) OF ITS SPREAD.

(i) *In order to Prevent the Appearance of the Disease* the ideal is obviously to avoid the introduction of carriers into barracks, establishments, and ships; but as it is impossible to examine bacteriologically all the men at such frequent intervals, so as to detect intermittent carriers (*vide* below), this cannot be attained.

Before the occurrence of cases and the isolation and examination of their contacts, the only promising procedure for the detection of carriers would be bacteriological examination of swabs from boys or men who for the following reasons—the presence of nasal or pharyngeal catarrh associated with headache or fever, or the occupation of overcrowded quarters—might possibly be carriers. The boys' training establishments, especially those such as the "Impregnable," the "Powerful," and Shotley, where outbreaks have previously occurred, are more likely to harbour carriers and originate cases of the disease. It might therefore be advisable to examine bacteriologically those boys who develop catarrhal symptoms. This investigation should be undertaken some little time before an epidemic may be expected, and, judging from recent experience, the most suitable time would be in the month of December. In order to avoid the risk of intermittent carriers, namely, those who are alternately positive and negative bacteriologically, *it would be advisable to invalid out of the Service all those who have recovered from an attack of cerebro-spinal fever.* It is true that such persons have usually been proved to be negative before leaving the hospital, and that the carrier state generally lasts for a short time only—commonly three weeks. On the other hand, periodic or intermittent carriers are known to exist, and if these can be eliminated at the comparatively small cost of invaliding those who recover from the disease (about 74 would be the loss between August, 1914, and August, 1915), a distinct advantage would be gained.

Overcrowding should be prevented, and a cubic space of 800 ft. per man when the men live, mess, and sleep in the same room, and of 600 cubic ft. when they sleep only in the room, should be maintained. Steps to remedy the overcrowding in the "Impregnable" and "Powerful," and at the Royal Naval Barracks, Devonport, should be taken without delay. Further, when catarrhal diseases break out, the cubic space should be increased by diminishing the number of men in the infected rooms. Constant and adequate



ventilation of the sleeping rooms should be assured by the system of night patrols, who see that the windows and ventilators are not closed during the night.

As recent recruits are specially picked out by the disease, the depressing conditions to which they are liable should as far as possible be mitigated. The risk of over-fatigue from unaccustomed drills and route marches should be borne in mind, and especially avoided after vaccination or antityphoid inoculation.

As catarrhal diseases, such as influenza, catarrh, tonsillitis, and sore throat, appear to play some part in favouring the outbreak of cerebro-spinal fever, and often precede its appearance and coincide with its prevalence, every effort to limit their spread should be made. Special care should be taken to prevent the common use of handkerchiefs and towels. Isolation when possible should be carried out and, as already mentioned, the cubic space in the infected rooms should be increased. The throats and noses of the patients should be douched or sprayed with a mild antiseptic lotion, such as warm solution of permanganate of potassium, 1 in 1,000. When convalescent the men should be carefully protected from fatigue.

(ii) *Measures to Prevent the Spread of Cerebro-spinal Fever when the Disease has appeared.*—During the late epidemic this problem, which is rendered specially difficult by the exigencies of the Service in war-time, was thoroughly taken in hand, and it is therefore unnecessary to reiterate the details and the established routine, such as the closing and disinfection of the dormitory in which a case occurs, the sterilization of the clothing, beds, mattresses, pillows, sheets, blankets, towels of the patient and of his immediate contacts, and the isolation and bacteriological examination of contacts.

The evidence that carriers spring up freely around a case has raised the question if the usual number of contacts sent for bacteriological examination—namely six (the two who sleep and the two who mess on each side of the patient, and his two most intimate friends)—is sufficiently large to catch all the infected contacts. Examination of remote contacts has therefore been carried out in some instances in which isolation of close contacts did not arrest the outbreak. The success which attended this step at Plymouth and Chatham (*vide* pp. 3, 4) justifies the belief that a more extended examination of contacts is desirable. This extension might consist in inspection of the remote contacts in the same dormitory and mess-room, and the isolation of those found to have naso-pharyngeal

catarrh until they have been swabbed and proved bacteriologically not to be meningococcic carriers. A list of the friends of the patient might also be made the basis for an extension of the examination of contacts. It would probably be wise to examine ten to twelve contacts as a matter of routine, even when an isolated case occurs. When the contacts are isolated it would be advisable to segregate those with naso-pharyngeal catarrh—and therefore more prone to be carriers—from those in ordinary health. This would tend to prevent the extension of the carrier state among the contacts during their ten days of quarantine. Contacts, and especially carriers, with catarrh should be instructed not to swallow the naso-pharyngeal mucus, which should be carefully collected and burnt. The urine should be dealt with so as to avoid any risk of infection from this source.

The douching of the nose and throat of contacts and carriers twice or thrice daily should be carried out under medical supervision, and it is important that mild antiseptics only, such as warm permanganate of potassium solution, 1 in 1,000, dilute saline solution, or dilute boracic acid solution, should be employed, and that the more powerful antiseptic solutions, which may impair the resistance of the naso-pharyngeal mucous membrane and so favour persistence of the carrier state or lead to cerebro-spinal fever in a carrier, should be avoided. The isolated contacts and carriers should sleep in well-ventilated wards, rooms, or tents, with ample cubic space, should be as much in the sun and fresh air as possible—exposure to cold, east and north-east winds being avoided—receive a generous diet, and their general hygiene should be carefully supervised. As long as the contacts are isolated in good circumstances, it is not essential that they should be actually in hospital, and a camp or buildings, preferably in the neighbourhood of a medical establishment, would meet the case.

When an outbreak of cerebro-spinal fever is recognized, any case even possibly of this nature, such as toxæmia and severe influenza, especially of the nervous or gastro-intestinal types, should be isolated from the sick bay; and catarrhal conditions, such as influenza, catarrh, tonsillitis, and sore throat, dealt with in the manner described above.

It is advisable that swabs from the throats of the surgeons, nurses, and sick berth staff in attendance on the patients should be periodically examined so as to detect carriers; and that cases of catarrh, sore throat, malaise, or headache among those in contact with the patients should be promptly isolated and examined



bacteriologically, as some of them may be examples of abortive cerebro-spinal fever. Lieut. M. Culpin, R.A.M.C., F.R.C.S., has mentioned to me cases of this abortive form of the disease among the orderlies in the wards for cerebro-spinal fever at the Alexandra Hospital, Cosham.

The arrangements for the quarantine of men before being drafted from infected barracks have been amply justified, for it is most remarkable that from the beginning of the War until August 1, 1915, there were only twelve cases on sea-going ships. In the light of this successful result the quarantine, which leaves a wise margin for variation in the probable length of the incubation period, should not be relaxed.

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